California's conversion of forests and wildlands as a component of Statewide CO2 equivalent (CO2e) emissions

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It is often mentioned that deforestation at the global level is a significant component for CO2 emissions. In California the preponderance of evidence supports the position that our forests are a net sink of CO2. Forests owned by government, families, and the forest industry are all adding inventory faster than they are harvesting timber or selling land for future conversion (http://frap.cdf.ca.gov/assessment2003/). Losses to wildfires are high in some years, but over decades are still far less than forest growth. It is also clear that California's expanding population is driving the conversion of forests and other wildlands into primary and vacation residential parcels. In terms of potential losses of carbon, it is important to get an accurate understanding of the scale of the loss of carbon and the level of leakage that will be experienced from specific projects. For example, a recent analysis of the carbon sequestration from the forest preservation policies in Oregon and Washington estimated that more than 90% of the project-level sequestered carbon was cancelled out by increased harvests from other forests in the United States and in Canada (Murray et al. 2004. "Estimating Leakage from Forest Carbon Sequestration Programs", Land Economics, (80) 109-124). It would not be surprising if an equally high leakage could occur for lands purchased to stop residential conversion.

It is also valuable to compare the CO2e losses due to residential conversion with California's overall annual CO2 emissions and target reductions. With 2020 reduction targets of 174 million metric tons of CO2, it is important not to divert scarce regulatory and market enforcement resources to sectors where the regional certainty of project level benefits may be hard to ascertain. In round numbers, the following analysis estimates that approximately 0.5 million metric tons of CO2 are lost annually from the conversion of forests and woodlands to primary and vacation residential uses. This is probably an order of magnitude smaller than carbon losses to wildfires on these same lands. The costs of reducing either of these types of losses will vary and should be judged on their marginal cost per CO2 ton.

The combination of the digital coverages in the 2000 Census with statewide or national landcover maps has allowed many researchers such as California's Fire and Resource Assessment Program (http://frap.cdf.ca.gov/assessment2003/) and the USFS PNW to calculate both current residential uses within areas dominated by other vegetation for 2000 and the change between 1990 and 2000. The following set of tables and explanations works the data developed by FRAP.

The 1990-2000 land use and demographic comparisons allowed FRAP to look at residential expansion at a variety of densities across all land covers in the state with the same methodology. For this analysis we are ignoring identified urban areas in 1990 that also had a fair number of undeveloped areas and low density areas that received many new residents. For both irrigated agricultural lands and wildlands, most of the area identified by census blocks was characterized by relatively few houses per square mile.

Table 1: Annual acreage in census blocks of different densities

Annual New Residential Footprint in 1990 Agriculture lands and Wildlands	5-20 acre parcels	1-5 acre parcels	<1 acre parcels	All 'residential conversion'
Forests and Woodlands	23,278	3,320	1,652	28,249
Irrigated Agriculture, Grasslands, Shrublands	49,353	5,071	11,133	65,557
Total Agricultural and Wildands to Residential	72,630	8,391	12,785	93,806

Not surprisingly, the land closest to existing residential lands – irrigated agriculture and grasslands in Northern California and shrublands in Southern California – experiences more conversion, especially to dense subdivisions, than the forests and woodlands. Statewide, only one third of the total converted acres occurs in forests and woodlands. However, the higher biodiversity, numerous wildlife habitat values, and carbon storage benefits make the trends in forests and woodlands more important than the initial numbers suggest.

The following table provides a more detailed breakdown within the major types of forests and woodlands. Conifer forests are the largest single category in terms of acres but have a much lower percentage of conversion than either hardwood forests or hardwood woodlands because there are more private acres of conifer forests. It is also worth pointing out that a much greater proportion of the acres with new parcels have a very low density of new houses. 82% of the total acres are in the '5-20 acre parcel' category. While this is high enough to be considered 'fragmentation' from many wildlife habitat and biodiversity perspectives, it is less significant in terms of the areas of direct and total conversion.

Table 2: Annual growth of new residential areas by density and forest type

Census blocks acres with new homes	5-20 acre parcels	1-5 acre parcels	<1 acre parcels	All 'residential conversion'	Pct of All
Conifer Forest	9,223	971	578	10,772	38%
Hardwood Forest	6,369	1,069	254	7,692	27%
Hardwood Woodland	7,062	1,210	795	9,066	32%
Conifer Woodland	625	70	26	720	3%
Total	23,278	3,320	1,652	28,249	100%
Percent of Total	82%	12%	6%	100%	

Field observations of new developments in forests and woodlands suggest that the area of direct and total conversion, that is the total removal of natural vegetation and replacement with houses, outbuildings, irrigated lawns, and driveways is often around ½ acre – an area 150' by 150'. The following table illustrates the 'direct impact acres for both ½ acre sites as well as a larger 1 acre per residence estimates. The direct impact area is shown as a percent of the average parcels sizes for each category – 10 acres, 3 acres, and 0.6 acres.

Table 3: Conversion from total parcel acreage to estimated direct area impact

Census tract acres with new homes	5-20 acre parcels	1-5 acre parcels	<1 acre parcels
Assumed median parcel size (acres)	10	3	0.6
Percent of site with direct impact with ½ acre per residence	5%	17%	83%
Percent of site with direct impact with 1 acre per residence	10%	30%	100%

The following table uses the larger 1 acre per house impact area to develop estimates of the direct impact acres by forest/ woodland type as well as by census tract density class. The estimate of direct impact acres is important for at least two reasons. One is to get an idea of the magnitude of the potential water quality impacts of new residential development in forests and woodlands. The other is for use in estimating how many trees, and therefore carbon, is removed in the process of residential development. The latest round of forest inventory data for California produced by the Forest Inventory Analysis (FIA) team of the USFS-PNW (http://www.fs.fed.us/pnw/fia/) provides good estimates of biomass, carbon, and equivalent CO2 stocking per acre. In round numbers, they project 140 CO2 tons/acre for conifer forests, 100 CO2 tons/acre for hardwood forests, and 40 CO2 tons/acre for hardwood woodlands and conifer woodlands. These numbers are for all lands so they probably overestimate the stocking levels of the private lands that typically have lower stocking levels than public lands.

Table 4: Direct Impact Acres (house site, yard, driveway, etc) by forest types

Census tract acres with new homes	5-20 acre parcels	1-5 acre parcels	<1 acre parcels	All 'residential conversion'	Pct of Total
higher estimate of direct impact	10%	30%	100%		
Conifer Forest	922	291	578	1,792	36%
Hardwood Forest	637	321	254	1,211	24%
Hardwood Woodland	706	363	795	1,864	37%
Conifer Woodland	62	21	26	109	2%
Total	2,328	996	1,652	4,976	100%
Percent of Total	47%	20%	33%	100%	

Combining the biomass or CO_2 equivalent stocking numbers with the direct impact acres gives us a table of projected annual CO_2 losses for a continuation of 1990-2000 trend in residential conversion of wildlands. The estimates for both the actual size of the direct impact areas as well as the stocking per acre are on the high side, so these estimates should be considered as also being on the high side.

Table 5: Estimate of CO_2 tons lost to conversion by density and forest type

Biomass loss	5-20 acre parcels	1-5 acre parcels	<1 acre parcels	Annual (tons)	Pct of Total
Est. Percentage of Biomass removed	10%	30%	100%		
Conifer Forest	129,118	40,778	80,920	250,816	56%
Hardwood Forest	63,686	32,076	25,380	121,142	27%
Hardwood Woodland	28,247	14,518	31,788	74,553	17%
Conifer Woodland	2,499	836	1,020	4,355	1%
Total	223,550	88,208	139,108	450,866	100%
Percent of Total	50%	20%	31%	100%	

It is now worth comparing the acres of forests and woodlands that experience some level of residential development versus the acres of forests and woodland where most of the tree-based carbon is removed. The near sixfold difference in acreage demonstrates that the overlap between the loss of forest based wildlife habitat is imperfect in comparison to the loss of tree-based carbon. The logical corollary is that carbon market payments can not fully cover the costs of forest-based habitat losses. Alternative financing for open space preservation will be needed to accomplish goals that preceeded the emerging carbon offset markets.

Table 6: Acres of Impacted Census Acres v. Direct Impact Acres

Land Cover	Impacted Census acres	Direct Impact acres
Conifer Forest	10,772	1,792
Hardwood Forest	7,692	1,211
Hardwood Woodland	9,066	1,864
Conifer Woodland	720	109
Total	28,249	4,976